Data Distribution & Processing CSCI
Data Fusion CSC
Requirements Design Panel 2

May 28, 1997
Version 1.0

1. Data Distribution & Processing CSCI

The Data Distribution & Processing CSCI is composed of the following CSCs:

Data Distribution CSC, Data Fusion CSC, and Data Health CSC.

1.1 Data Fusion CSC Introduction

1.1.1 Data Fusion CSC Overview

Data Fusion involves computation using constants, FD measurement values, health values or other fusion values.   The Data Fusion CSC provides the capability to perform Data Fusion processing on specified FDs received at the DDP, based on algorithms defined for the associated FDs.

Data Fusion CSC Overview is as follows:
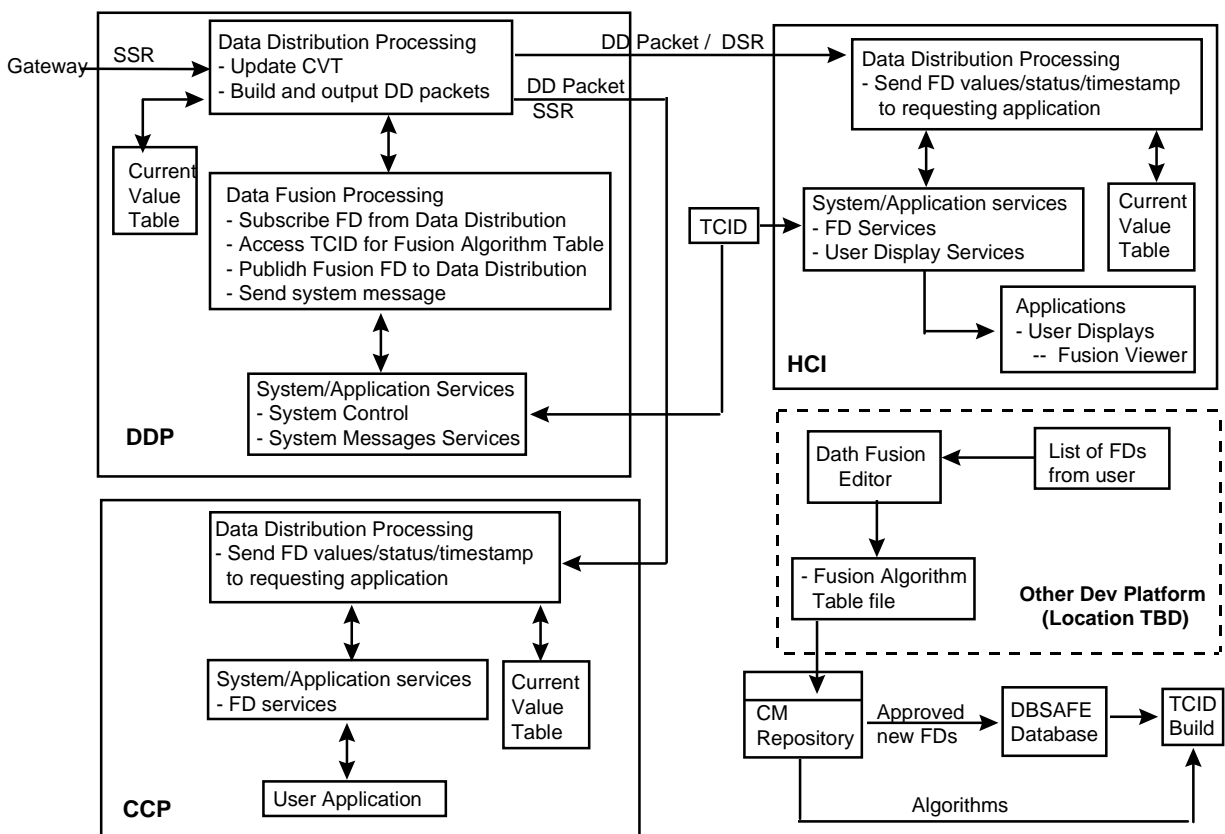
1.1.2 Data Fusion CSC Operational Description

Data Fusion can be divided into two segments, a user development segment, and a run time segment.
The user development segment involves:

- User off-line definition of Data Fusion Algorithms via the use of a Data Fusion Editor
- Integrate Test build of the Data Fusion Algorithm Table

The run time segment consists of:

- Loading the Data Fusion Algorithm Table during DDP initialization
- Applying data fusion on FDs received at the DDP by the Fusion processes
- Storing computation results in the CVT and making the data accessible by applications via Data Distribution.

1.2 Data Fusion CSC Specifications

1.2.1 Data Fusion CSC Ground Rules

1. Data Fusion inputs can be any valid FDs available in the data stream.

2. The maximum number of FDs used in a single calculation is 100.

3. The maximum number of FD samples in a single calculation is 200.

4. The user will specify Data Fusion FD data types using the defined engineering units data types (Refer to Appendix C).

5. Data Fused FDs shall be treated the same as any other FDs.

6. Fusion calculations/formulas may contain user-changeable coefficient.

7. Fusion FDs and Fusion algorithms cannot be created in a real-time environment. They must be edited/created prior to TCID build.

8. Data Fusion will not support user overriding Fusion output and inhibiting Fusion calculation for Redstone.

9. The user will associate a fusion algorithm with a Fusion name, or RSYS name.

10. There will be a single algorithm table per TCID.

11. Data Fusion CSC will make use of Data Distribution API to obtain and store fusion data from/to the CVT and / or queued services.

12. Data fusion data will be made available for applications access at the DDP, CCP, and HCI via Data Distribution.

13. Applications with the exception of Data Health manager and Data Fusion manager, will obtain fusion data via FD Services.

14. Data Fusion will be performed on a one-pass execution basis, so that processing is done with a cohesive set of data.

15. Data Fusion supports forward fusion only. Fusion output can not be used as Fusion input on the same processing cycle.

16. The user may alter user-changeable coefficient at real-time as needed to change the data fusion calculation but not the formula.

1.2.2 Data Fusion CSC Functional Requirements

The following Data Fusion Functional requirements are listed under two sections:

- Data Fusion Editor
- Data Fusion run time processing

The requirements for the Editor and run time processing will be used as specification for COTS evaluation. If a viable COTS tool is found, the tool will be made available for users for the Redstone Delivery.

1.2.2.1 Data Fusion Editor (DFE)

1. DFE will provide an Graphical User Interface (GUI) allowing user to:
   a. select input FDs using a list of FDs in a user specified file
   b. define fusion algorithms/formula using predefined operators list
   c. select output FD
   d. enter data validity requirement(s) of a fusion FD. User may specify formula for resultant health determination of the Fusion FD.
   e. query and search other data fusion FD and their compositions to help create new ones
      - Provide filtering options for search
         i. FD name
         ii. group of FDs
         iii. Fusion name
         iv. RSYS name
         v. Keyword
   f. copy, cut, and paste of an existing Fusion algorithm to create a new algorithm
   g. modify a fusion algorithm
   h. save algorithm definition to an existing file
   i. save algorithm definition to a new file (user defined)
   j. exit without saving
   k. test the new algorithm (debug option)
      - Allow user to enter values of input FDs
      - Allow user to create value of user changeable variable
      - Output resulted FD value and status
   l. print FD and associated algorithm

2. DFE will display error messages when:
   a. A duplicate fusion output FD is entered. Upon which the user will be prompted with a "override" message.
   b. Inconsistent data types are entered

3. DFE will provide On-Line Help

4. DFE will support prioritization of fusion algorithms

5. DFE will provide the following Arithmetic Operators:
   a. Addition (+)
   b. Subtraction (-)
   c. Multiplication (*)
   d. Division (/)
   e. Modulus

6. DFE will provide the following Relational Operators:
   a. Less Than (<)
   b. Greater Than (>)
   c. Less than or equal to (<=)
   d. Greater than or equal to (>=)
   e. Equivalent (=)
   f. Not equivalent (/=)

7. DFE will provide the following Logic Operators:

   a. AND
   b. OR
   c. XOR
   d. NOT

8. DFE will provide the following Bitwise Operators:
   a. AND
   b. OR
   c. XOR
   d. Left Shift
   e. Right Shift
   f. Ones complement
   g. Twos complement

9. DFE will provide the capability to support the "if then else" conditional operator either inside or outside of the equation/calculation

10. DFE will provide the capability to support the Power Function $(a**b)$

11. DFE will provide the capability to support the Exponential Function $(e**x)$

12. DFE will provide the capability to support the Square Root Function

13. DFE will provide the capability to support bi-directional conversions:
    a. knots $<=>$ miles per second
    b. degrees $<=>$ radian
    c. BCD $<=>$ Decimal
    d. hours $<=>$ minutes
    e. Time of Day (TOD) $<=>$ Greenwich Mean Time
    f. meters $<=>$ feet
    g. miles $<=>$ feet
    h. Centigrade $<=>$ Fahrenheit
    i. pounds $<=>$ grams
    j. pounds per sqare inch $<=>$ pounds per sqaure foot
    k. gallon $<=>$ litter

14. DFE will provide the capability to support the following mathematical functions:
    a. Absolute
    b. *ln*
    c. Log10

15. DFE will provide the capability to support the following Trigonometric Operators:
    a. sin()
    b. cos()
    c. tan()
    d. cot()
    e. sec()
    f. csc()
    g. atan()

16. DFE will support the Average function:
    a. for changed values.
    b. for values over time

17. DFE will support the Minimum/Maximum Function
    a. e.g., Given floating point value of 1.5 : min returns 1 and max returns 2

b. e.g., Given a number of FDs : min returns the lowest and max returns the highest
18. DFE will support predefined constants:
    a. pi
19. DFE will support filtering operators:
    a. e.g., spike capture
    b. e.g., spike elimination
    c. e.g., digital filter
20. DFE will support data smoothing operator
    a. Sample rate reduction (e.g., 100 sample/sec to 1 sample/sec)
21. DFE will support data differentiation and integration operators:
    a. 1st derivative based on time
    b. integral based on time
22. DFE will support health operators:
    a. test if an FD is failed
    b. test if an FD is in warning condition
    c. test if 'x' of 'y' conditions are true (voting logic)
23. DFE will conform to operator procedures. The DFE will generate the Data Fusion Algorithm Table consisting of but not limited to the following information:
    a. input FD(s)
    b. output FD
    c. algorithm to generate out value
    d. algorithm to determine output health
    e. object name
    f. fusion name or RSYS name

1.2.2.2 Data Fusion Manager (DFM) in the DDP

1. DFM will execute the operation defined in the Algorithm table
2. DFM will make fused FDs available to be incorporated to the Data Distribution packets.
3. DFM will support prioritizing fusion algorithm execution.
4. DFM will provide the capability allowing user to control when fusion FDs are executed:
    a. Executes whenever an input or a set of inputs changed within a SSR cycle. (default)
    b. Executes whenever a fusion process is scheduled.

1.2.2.3 Data Fusion Manager Future Requirements

1. The Data Fusion Manager will capture run time errors and display them via an appropriate system messaging mechanism. (post Redstone).

2. The Data Fusion Manager will provide an application interface allowing application to:
    a. inhibit processing on any user selected Fusion FDs (post Redstone).
    b. activate processing on any user selected Fusion FDs (post Redstone).
    c. override a Fusion FD value. The changed value will be persistent. (post Redstone).

1.2.3 Data Fusion CSC Performance Requirements

The following performance requirements are under RID review process, subject to change.

1. The Data Fusion will process up to the "system maximum data bandwidth" of FDs with one fusion calculation per change.

2. The Data Distribution shall support the "system maximum data bandwidth", plus 5,000 (20%) Data Fusion updates per second.

1.2.4 Data Fusion CSC Interfaces

Data Fusion Context Diagram

Subscribed FDs

Data Distribution → Data Fusion

Publish FDs.

Disable/enable an Fusion FD

Applications (via FDservice)

TCID

Data Fusion Algorithm Table

Send system message

System Messages

System config info

System Config Reqs

System Control
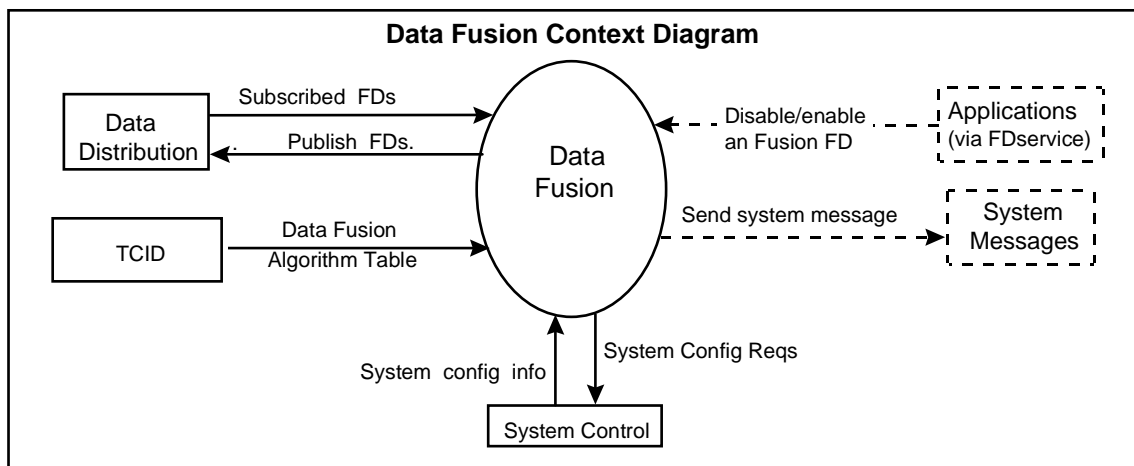
1.2.5 Data Fusion CSC Data Flow Diagram

External

```
┌──────────────┬──────┐                      ┌────────────┐ ┌ ─ ─ ─ ┐      ┌ ─ ─ ─ ─ ─ ─ ─ ┐
│              │      │   Subscribe  FD      │            │  Fusion        │               │
│ Data         │ DD   │─────────────────────▶│   Data     │  API   │      │ FD            │
│ Distribution │ APIs │                      │   Fusion   │ ◀──────┼ ─ ─ ─│ Service       │
│              │      │   Publish Fusion FD  │            │ │      │      │ API           │
│              │      │◀─────────────────────│            │                │               │
│              │      │                      └────────────┘ └ ─ ─ ─ ┘      │               │
│              │      │                            ▲                        │               │
└──────────────┴──────┘                            │                       │               │
        ▲                            ┌─────────────┴──────┐                │               │
        │                            │   TCID             │                │               │
        │                            │ - Fusion Algorithm Table            │               │
        ▼                            └────────────────────┘                │               │
   ┌─────────┐                                                             └ ─ ─ ─ ─ ─ ─ ─ ┘
   │  CVT    │
   └─────────┘
```

Disable/enable an Fusion FD

┌ ─ ─ ─ ─ ─ ─ ┐
│ User   │
│ Application │
└ ─ ─ ─ ─ ─ ─ ┘

Internal
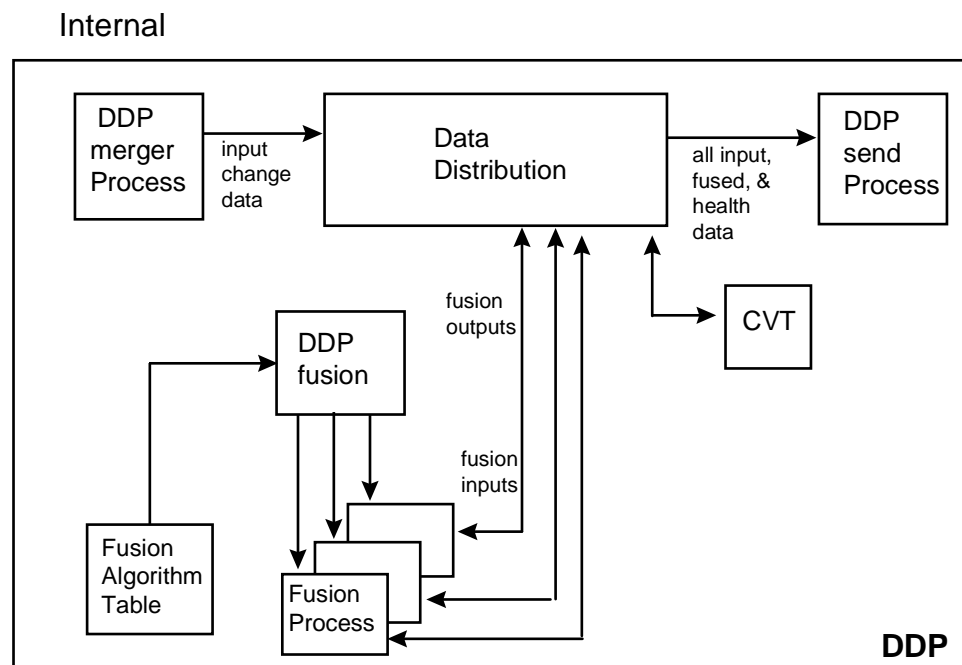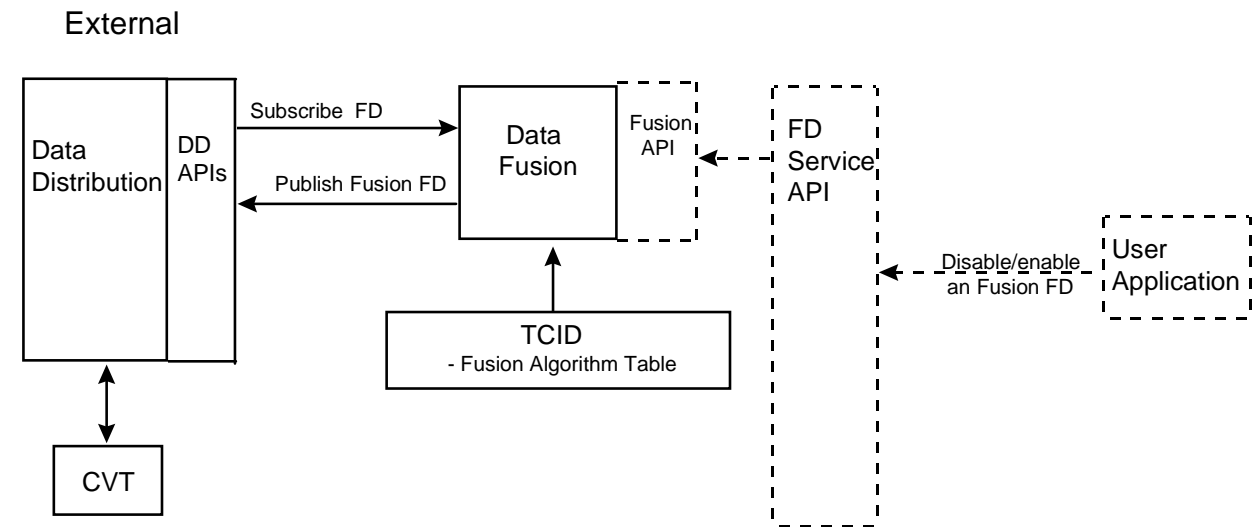
APPENDIX A

Statement of Work

- Define the list of logical and mathematical function required by the users for Data Fusion FDs.
- Define the list of logical and mathematical functions required by the users for Data Fusion Health.
- Define the Data Fusion FD types.
- Determine if a COTS tool can be utilized and provide the selected tool.
- Provide the initial Pre-build Data Fusion Editor.
- Provide the Data Fusion capability as part of the CLCS DDP Group.
- Provide the capability for Fused FD's to be utilized by the Data Distribution Manager for both the CCP and the HCI.
- Provide the capability to add fused FD's to the Data Bank.
- Provide the capability for Fused FD's in the Test Build process
- Provide an initial System Viewer with the minimum capability to view fused FD's, including the Fused FD value, associated input FD values and the function being used to generate the Fused FDs.
- Incorporate fused FDs into the record and retrieve capability with same capability as Gateways FD's and User Application Derived FD's.
- Provide the capability for the Data Fusion Function to be utilized in both Operational and Application environment (eg.. DDP & HCI/DDP/CCP/GW/MM Logical Subsystems).
- Provide performance data for system modeling
  Post-Redstone Activities
- *Provide capability to inhibit processing on individual Fusion FD's.*
- *Provide the capability for Fused FD's to be used utilized by the Constraint Manager Function.*

APPENDIX B - Sample Editor to be reviewed with User Group
(SAMPLE ONLY)

D a t a   Fusion   E d i t o r

FD Selection

Fused FD Name ☐ ok

☐ △ ▽

[Refresh] [Execute] [Print] [Cancel]

FD Algorithm

[FD Name] [Operator] [Function] [Conversion] [Polling] [Display] [Description] [Test]

| Arithmetic | Average |
| Relational | Min./Max. |
| Logic |
| Trigonometic |
| Bitwise |
| Time Based |

| 0 | 1 | 2 | 3 | 4 | 5 | Numeric Values ok

| 6 | 7 | 8 | 9 | · | % | ☐

FD Name ok

☐ △ ▽

(pop-up display area - operator, function, conversion, polling)

FD Information

FD Display △

▽

(SAMPLE ONLY)

FD Algorithm: pop-up displays

FD Name	Operator	Function	Conversion	Polling	Description	Display	Test

Operator	Function
Arithmetic	Average
Relational	Min./Max.
Logic	
Trigonometic	
Bitwise	
Time Based	

Operator

| Arithmetic | + | − | * | ÷ | mod | ** | e** | abs | log | log10 | Pi | (|) |

| Relational | < | > | ≤ | ≥ | = | ≠ |

| Logic | and | or | xor | not |

| Trigonometic | sin | cosin | tan | cot | sec | csc | arctan |

| Bitwise | and | or | xor | ◄ | ► | ones | twos |

| Time Based | over time | time assoc | trend anal | time conv |

Function

| Average | N samples | N interval | N period | median |

| Min./Max. | integer | actual |

Conversion

| Conversion | kt:mi | dg:rd | bcd:dec | hr:min |

Polling

| Polling | N samples | N interval | N period |

Data Fusion Editor - Text Description

The Data Fusion Editor (DFE) provides a graphical user interface allowing users to update fused FDs. Updating consists of the adding, changing, deleting, querying, and printing functions. Adding allows for the creation of a new fused FD. Changing allows for the modification of an existing fused FD. The deleting and querying (viewing without changing) functions will not be supported in this initial data fusion editor. Printing allows for the producing of a printed copy of a new or existing fused FD.

The DFE screen is divided into three areas: FD Selection, FD Algorithm, and FD Information. The FD Selection area contains a Fused FD Name Box and four command buttons. The name of the fused FD can be manually entered or selected from a scrolling list in the Fused FD Name Box. The list of names is scrolled by clicking on the up and down arrows. (The scrolling feature for fused FD names will need to be improved because of the large number of FDs, but for the Redstone delivery only a small set of FDs will be used.) After the correct name is displayed in the fused FD box, the OK box is clicked to accept the name. The Refresh button will redisplay the screen, disregarding any updating of the fused FD. The Execute button will replace the previous fused FD with the updated settings. The settings include the fused FD name, algorithm, and description. The Print button will produce a printed copy of the fused FD settings. The Cancel button will leave the DFE screen.

The FD Algorithm area is used to construct the algorithm. It contains a FD Name Box, a Numeric Values Box, and eight command buttons. The name of the FD can be manually entered or selected from a scrolling list in the FD Name Box. The list of names is scrolled by clicking on the up and down arrows. After the correct name is displayed in the FD box, the OK box is clicked to accept the name. (The scrolling feature for the FD names will need to be improved because of the large number of FDs, but for the Redstone delivery only a small set of FDs will be used.) Numeric characters, a decimal point, and a percent sign can be manually entered or selected using displayed buttons for the Numeric Values Box. After the correct value is in the numeric value box, the OK box is clicked to accept the value. The FD Name button is selected to indicate a FD name will be added to the algorithm. The cursor moves to the FD Name Box. The Operator button displays a pop-up menu with the following operator actions: Arithmetic, Relational, Logic, Trigonometric, Bitwise, and Time Based. Each of these operator actions display a list of buttons that can be selected. These buttons are shown in the pop-up display area to the right of the FD Name Box. The Function button displays a pop-up menu with the following function actions: Average and Min./Max. Both of these function actions display a list of buttons that can be selected. The Conversion button displays a list of buttons that can be selected. The Polling button displays a list of buttons that can be selected. The Display button toggles the FD Information area to display mode. The Description button toggles the FD Information area to description mode. The Test button examines the algorithm for syntax errors. It does not check for logic errors. If an error is detected, the FD Information area toggles to error message mode. The Execute command button of the FD Selection area can not be selected until the algorithm has been tested and is without errors.

The FD Information area has three modes: FD Display, FD Description, and FD Error Message. The FD Display mode shows the algorithm as it is being created or modified. The FD Description mode allows for the entering of a narrative description of the fused FD. The FD Error Message mode displays error messages when testing the algorithm.

APPENDIX C - Engineering Units Data Types

1.